Department of Pesticide Regulation

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MEMORANDUM

TO: John Sanders, Branch Chief
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FROM: Bruce Johnson, Senior Environmental Research Scientist
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DATE: September 24, 1999

SUBJECT: MONITORING RESULTS FROM A COMPARISON TEST OF BEDDED TARPED APPLICATION EQUIPMENT.

Introduction - Methyl bromide is widely used as a preplant soil fumigant for control of nematodes, fungi, diseases and weeds. The Department of Pesticide Regulation (DPR) and county agricultural commissioners have implemented permit conditions, including buffer zones, to mitigate unacceptable methyl bromide exposure. Buffer zone distances are set so that concentrations measured at this distance do not exceed 0.21 parts per million (ppm; 24-hour time-weighted average). The buffer zone distances for specific application methods have been determined from data received and evaluated by the Department to date. For each method the permit conditions specify the depth of injection, type of injection shank, tractor implements, etc. Over time, some equipment has been modified to meet various field conditions. These modifications may require revisions to the buffer zone requirements.

Vegetable and strawberry growers commonly use a tarped bed application (method 9 and 9.1) where the area to be fumigated is disced and formed into beds before application. The methyl bromide is then injected into the prepared beds and the tarpaulin is secured immediately over the beds with the same equipment; the furrows are left untarped. The methyl bromide is injected into the soil at a depth of at least six inches and no deeper than the bed height. The injection tubes are welded to chisels or shanks that curve to the rear, with two to three chisels per bed shaper. The older equipment had closing shoes or rollers attached to close the opening left at the soil surface by the chisels. Newer equipment has been modified with a bed shaper to close the soil.

The California Strawberry Commission determined that bed fumigation equipment currently consists of two general types: A "Shank-in" type in which shanks are mounted inside the bed shaper unit of the fumigation equipment, and a "Shank-ahead" type in which shanks are mounted ahead of the bed shaper unit of fumigation equipment. The Strawberry Commission monitored applications by both equipment types to evaluate the effectiveness of the buffer zone distances for the application methods.

Materials and Methods – Two application areas were selected for the test, Seal Beach (Orange County) and Santa Maria (San Luis Obispo County). Two types of application rigs were selected as the test equipment. The treated area consisted of three 210 feet x 210 feet (one-acre) plots at each location. An untreated buffer, measuring at least 498 feet was provided between adjacent plots. The plots were oriented within the field perpendicular to the prevailing wind direction to avoid interference between adjacent plots.

At each location a one-acre application was made with each representative shank and bed shaper. In addition, a third one-acre plot was treated with methyl bromide by a shallow broadcast tarped application as a standard comparison. The plot dimension and areas for both areas are presented in Table 1. The formulated product used for all the applications was 67 percent methyl bromide/33 percent chloropicrin. The application rates for all the plots are listed in Table 1. The cover used for the bed applications was a 1.5 mil, black tarpaulin produced by Mid South Extrusion, Inc. with a permeability value of 6.67. The tarpaulin used on the broadcast application was a 1 mil, clear tarpaulin produced by Dow-Armin.

Ambient air samples were collected at eight locations around each one-acre plot. The samples were collected with charcoal tubes (SKC 226-38-02) attached to SKC model XR4 air samplers with low flow adapters, or SKC model XR8 air samples at the collocation sites. The flow rate was calibrated to 15 ml/min at the beginning of each sampling period and checked at the end of the period. The eight samplers were located approximately 30 feet from the field, one on each side and corner.

The primary samples were analyzed by Bolsa Research Associates, Inc. The samples were extracted with ethyl acetate and analyzed using a gas chromatograph with an eletron capture detector. The collocated samples were analyzed by the California Department of Food and Agriculture's Center for Analytical Chemistry using a similar analytical method.

Seal Beach

The application in Seal Beach was made on June 24, 1999 (Figure 1). During a series of five periods samples were collected at the broadcast and shank-in bed application beginning with the start of application for both plots, 9:00 for the broadcast application and 10:00 for the shank-in bed application. The shank-ahead application did not start until 14:00 so the first sampling interval for that plot was dropped. The first sampling periods for the broadcast and shank-in bed application were less than six hours to allow all plots to be synchronized with beginning of application on the shank-ahead bed application plot for sampling period 2. The sampling interval times for each plot are located in Table 2.

The weather was clear with temperatures from 59 to 74 degrees Fahrenheit. Wind speeds ranged from calm to 16.5 miles per hour. The wind blew predominantly toward the north and northeast during the monitoring period with a secondary direction to the southeast. The soil was a loam or silt loam with 32 percent sand and 20 percent clay content with approximately 0.75 percent organic carbon. The soil had a pH of 7.7 and moisture content of 17.5 percent averaged across the entire field. The average bulk density was 1.38 g/cm^3.

Santa Maria
The application in Santa Maria was made on June 30, 1999 (Figure 2). During a series of five periods samples were collected at the broadcast and shank-ahead bed application. The shank-in application did not start until 14:00 so the first sampling interval for that plot was dropped. The first sampling period for the broadcast and shank-ahead bed application were cut to a five hour interval to allow all plots to be synchronized with beginning of application on the shank-in bed application plot for sampling period 2. The sampling times for each plot are located in Table 2.

The weather was clear with temperatures from 54 to 70 degrees Fahrenheit. Wind speeds ranged from very calm to 12 miles per hour. The wind blew predominantly toward the south and southeast during the monitoring period. The soil was a loamy sand with 80 percent sand and five percent clay content with approximately 0.3 percent organic matter. The soil had a pH of 6.7 and moisture content of seven percent averaged across the entire field. The average bulk density was 1.55 g/cm^3.

Collocated Monitors. A sample pump and tube was collocated at one sampling site at each plot during each sampling period. The assumed downwind site was selected for collocation. The sample tubes and air pump flow rate used were the same as the primary sample set up.

Meteorological data. A meteorological station was established near the center plot at each site. A Campbell Scientific 23X data logger was used to collect temperature, relative humidity, wind speed and direction. Temperature and relative humidity were collected using a Vaisala HMP35C temperature and relative humidity probe. Wind speed and direction were measured with RM Young 05103 wind speed and direction monitor at a height of 22 feet. This instrument has a starting threshold of about 1m/s for both wind direction and speed. Instantaneous measurements were taken every five seconds and two minute summaries were recorded in the data logger, downloaded and processed using WEATH5, a FORTRAN program which provides hourly summaries of scaler average wind speed and temperature and vector average wind direction (Johnson 1999).

Modeling methods. The U.S. Environmental Protection Agency (EPA) gaussian plume model, Industrial Source Complex (ISCST3) Dispersion Model (USEPA 1995 version 97363), was utilized to backcalculate average flux density during each period for each plot. The basis for this procedure is described in Ross et al. (1995). Requirements for the model are meteorological data consisting of hourly wind speed, wind direction, temperature, stability class and mixing height. Scalar average wind speed, vector average wind direction and average temperature were calculated from the on-site meteorological data using WEATH5, a FORTRAN program

(Johnson 1999). Stability class was estimated using standard EPA techniques based on sun angle, cloudiness, night/day, and wind speed (Budney 1977). Plot dimensions, sampler locations and directions were measured on site. This geometry was encoded into the ISCST3 control files for each plot. An initial simulation utilized an assumed flux density of of $100ug/m^2s$, which was subsequently adjusted by the multiplicative regression coefficient to estimate the average flux density during the period. The emission ratio was calculated by determining the time-weighted flux density for the maximum 24 hour period (or as close as possible), calculating the total mass emission, and dividing that by the application mass. Required buffer zones were calculated by using 24 hour time-weighted average flux using the meteorological data for the period of time upon which the 24 hour time-weighted flux calculation was based upon. If this procedure resulted in large differences between monitored and modeled values, then an hourly flux density was used based upon the period by period flux density estimates.

Results – Air concentrations ranged from no detectable amount to 0.187 parts per million (24-hour time-weighted average) for the broadcast application at Seal Beach and Santa Maria (Table 3). The air concentrations ranged from no detectable amount to 0.263 parts per million (24-hour time-weighted average) for the shank-ahead application at Seal Beach and Santa Maria (Table 4). Shank-in application concentrations ranged from no detectable amount to 0.259 parts per million (Table 5) for a 24-hour time-weighted average. Due to a delay in the start of the third plot at both the Seal Beach (shank-ahead) and Santa Maria (shank-in) the first 6-hour sampling period was dropped. The 18 hour time-weighted average for both applications are assumed to be representative of a 24-hour time-weighted average. The 24-hour time-weighted average concentration are also presented in Figure, 3-8.

The average laboratory recoveries for the samples analyzed by Bolsa Laboratory was 75 percent for the Seal Beach application samples and 74 percent Santa Maria application samples. The reported results have been adjusted respectively.

<u>Collocated Monitors</u> The results from collocated monitoring indicated good agreement between CDFA and Bolsa laboratories (Figure 9, Table 6). Unadjusted data was used for comparison in both cases. For Seal Beach, the regression was $y=0.92x+12$ ($r^2=76\%$, $p<.01$) and for Santa Maria was $y=1.19x-37$ ($r^2=82\%$, $p<.01$). In both cases, the slope was not statistically different from 1.0.

<u>Modeling results.</u> The period by period regression results used to backcalculate flux density are presented in Table 7. Given the lower sample size, a ten percent significance level was adopted, instead of a more customary five percent significance level. Of the 28 periods for which monitoring data were available, five periods gave regression results that were not significant. For these five periods, monitoring and modeled air concentrations were sorted, and the regression was performed on the sorted data.

Estimated flux densities ranged from a high of 425 micrograms per squared meter per second (ug/m^2s), during period 2 of the Seal Beach shank-ahead to a low of 15 ug/m^2s for the final shank-in period at Seal Beach. Period 2 of the Seal Beach shank-ahead treatment was actually the period during which the application was made, since this treatment was delayed. The high application flux density for shank-ahead at Seal Beach was consistent with the results from Santa Maria, where the application period for shank-ahead also displayed the highest flux density at 351 ug/m^2s. Generally, higher flux densities occurred within the first two periods, with a tapering off during the remaining periods. Generally, the broadcast treatment showed lower flux densities than either of the other treatments (Figure 10).

The Santa Maria shank-ahead treatment inadvertently received about 37% more than the intended application. Consequently, a flux density during period one adjusted downward by 37% would have yielded a value of 255ug/m^2s, roughly equivalent to the first period value of 278 ug/m^2s for the shank-in treatment at Santa Maria (Table 7).

Average time-weighted flux densities were calculated for each treatment at each location for the first 24 hours (Table 8). In some cases, a full 24 hours was not available, as had been originally planned due to problems starting some of the treatments. In these cases, the first two periods were used, with the hours totaling 18. The average flux densities for the first 24 hours reflect the general theme that the broadcast application resulted in lower flux densities. The shank-ahead resulted in the highest 24-hour time-weighted flux densities.

The 24-hour time-weighted flux densities were used to calculate emission ratios (Table 9). The lowest emission ratio was 0.13, for the Seal Beach broadcast treatment. The highest occurred with the Seal Beach shank-ahead at 0.77. Emission ratios were consistent between locations with the bedded application consistently higher than the broadcast. There was no clear-cut difference between the two bedded application treatments.

Both the shank-in and shank-ahead bed fumigation methods monitored here are currently assigned an emission ratio of 0.19 (method 9 in the permit conditions). However, the data are more consistent with the 0.50 emission ratio assigned to method 9.1, or the 0.70 emission ratio assigned to method 10. These data may indicate that all current bed fumigation methods have similar emission rates. These four fumigations, the two monitored for method 9.1, and the two monitored for method 10 have emission ratios ranging from 0.43 to 0.77. Only the single fumigation monitored for method 9, with an emission ratio of 0.045 appears different, and this method (the only one without a bed shaper) is no longer commonly used.

Two-way analysis of variance of the emission ratios and the maximum 24-hour concentrations found no significant effects of treatment or location on emission ratios (Table 10). The test, however, had a small number of degrees of freedom and any interaction effect between location and treatment was folded into the mean square error because there were not enough degrees of freedom to measure an interaction. Mean values for emission ratios were 0.23, 0.61 and 0.64 for broadcast, shank-in and shank-ahead, respectively. For maximum 24-hour average concentrations, analysis of variance found treatments were significant at the marginal level of 7.8%, while location was significant at 3.6%. Mean values of the maximum 24-hour average concentration were 0.12, 0.22 and 0.21 ppm for broadcast, shank-in and shank-ahead, respectively.

The required buffer zones ranged from <30 to 139 feet. At both locations, broadcast treatment did not require buffer zones to keep concentrations below 0.21ppm. At the Seal Beach location, neither shank-in nor shank-ahead required buffer zones. However, consistent with the average maximum concentrations by location (Table 10), the higher maximum concentrations at the Santa Maria location led to required buffer zones for shank-in and shank-ahead of 113 and 139 feet, respectively.

Attachment

References

Budney, Laurence J. 1977. Guidelines for air quality maintenance planning and analysis - Volume 10 (revised): Procedures for evaluating air quality impact of new stationary sources. Report No. EPA-450/4-77-001. U.S. Environmental Protection Agency, Office of Air and Waste Management, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

Johnson, B. 1999. Memorandum to Kean Goh on Description of WEATH5 program for processing data logger meteorological data for use with ISCST3. Dated September 16, 1999. Department of Pesticide Regulation.

Ross, L., B. Johnson, K.D. Kim, and J. Hsu. 1995. Prediction of methyl bromide flux from area sources using ISCST model. California Department of Pesticide Regulation Report EH 95-03.

U.S.EPA. 1995. User's guide for the Industrial Source Complex (ISC3) Dispersion Models. Office of Air Quality Planning and Standards Emissions, Monitoring, and Analysis Division. EPA-454/B-95-003a and addendum dated November 1998.

Table 1. Application masses in pounds and plot areas. Methyl bromide tanks were weighed before and after application to give the mass 'by weight'. In addition, computerized application equipment measured the applied mass at Seal Beach shown here in 'by computer' column.

Application Masses

	Seal Beach		Santa Maria	
	By Weight*	By Computer*	By Weight**	By Computer
Broadcast	277	277	286	NA
Shank-In	284	264	280	NA
Shank-Ahead	277	263	386	NA

Plot Areas

	Length (m)			
Seal Beach	E-W	N-S	Area (m2)	Acres
Broadcast	62.62	63.54	3978.9	0.98
Shank In	65.06	65.06	4232.8	1.05
Shank Ahead	63.84	64.91	4143.9	1.02
Santa Maria				
Broadcast	64.01	62.48	3999.3	0.99
Shank In	64.92	64.01	4155.5	1.03
Shank Ahead	64.62	64.01	4136.3	1.02

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Table 2. Idealized start and stop times for 5 periods of methyl bromide monitoring at Seal Beach and Santa Maria broadcast, bedded (shank in and shank ahead methods).

Seal Beach

	Broadcast		Shank-In		Shank-Ahead		
	Start	Stop	Start	Stop	Start	Stop	
1	900*	1400	1000*	1400	na	na	24-Jun
2	1400	2000	1400	2000	1400*	2000	24-Jun
3	2000	800	2000	800	2000	800	24-25 Jun
4	800	2000	800	2000	800	2000	25-Jun
5	2000	800	2000	800	2000	800	25-26 Jun

Santa Maria

1	900*	1400	na	na	900*	1400	30-Jun
2	1400	2000	1400*	2000	1400	2000	30-Jun
3	2000	800	2000	800	2000	800	30-Jun/1-Jul
4	800	2000	800	2000	800	2000	1-Jul
5	2000	800	2000	800	2000	800	1-2 Jul

*Application period

Table 3. Ambient methyl bromide air concentrations associated with the broadcast applications.

	Sampler		Methyl Bromide (ppm) for each Sampling Period					
			Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	24-Hour
Plot	Site	Distance	5 Hour	6 Hour	12 Hour	12 Hour	12 Hour	TWA [1]
Seal Beach	N	33 ft	0.018	0.023	**0.052**	**0.045**	0.050	0.049
	NE	32 ft	0.025	0.054	**0.021**	**0.047**	0.014	0.034
	E	32 ft	0.015	0.052	**0.033**	**0.016**	ND	0.024
	SE	33 ft	ND	0.022	**0.037**	**ND**	ND	0.019
	S	32 ft	ND	ND	**0.020**	**ND**	ND	0.011
	SW	32 ft	ND	ND	**ND**	**ND**	ND	ND
	W	33 ft	ND	ND	**0.009**	**ND**	0.012	0.005
	NW	35 ft	ND	ND	**0.031**	**ND**	0.042	0.016
Santa Maria	N	35 ft	**ND**	**ND**	**0.047**	ND	0.033	0.026
	NE	34 ft	**ND**	**ND**	**0.078**	ND	0.034	0.042
	E	30 ft	**0.107**	**0.170**	**0.229**	0.056	0.034	0.187
	SE	30 ft	**0.180**	**0.155**	**0.048**	0.071	0.034	0.105
	S	30 ft	**0.070**	**0.077**	**0.040**	0.039	0.030	0.056
	SW	30 ft	**ND**	**ND**	**0.048**	0.034	ND	0.026
	W	30 ft	**ND**	**ND**	**ND**	ND	ND	ND
	NW	33 ft	**ND**	**ND**	**0.014**	ND	ND	0.009

[1] the peak 24-hour time-weighted average is derived from the concentrations in bold. When the 24-hour average includes a period of no detectable amount, ½ the reporting limit was used to obtain the 24-hour average.

ND = No detectable amount; reporting limit = 0.006 ppm for 5-hr samples, 0.005 ppm for 6-hr samples and 0.003 ppm for 12-hr samples.

Table 4. Ambient methyl bromide air concentrations associated with the Shank-Ahead applications.

	Sampler		Methyl Bromide (ppm) for each Sampling Period					
			Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	24-Hour
Plot	Site	Distance	5 Hour	6 Hour	12 Hour	12 Hour	12 Hour	TWA [1]
Seal Beach	N	31 ft	N/A	**0.178**	**0.111**	0.095	0.050	0.134[2]
	NE	29 ft	N/A	**0.329**	**0.030**	0.050	0.009	0.130
	E	31 ft	N/A	**0.344**	**0.077**	0.021	ND	0.166
	SE	29 ft	N/A	**0.115**	**0.131**	ND	ND	0.125
	S	29 ft	N/A	**0.072**	**0.114**	ND	ND	0.100
	SW	30 ft	N/A	**ND**	**ND**	ND	ND	ND
	W	30 ft	N/A	**ND**	**0.044**	ND	0.010	0.030
	NW	30 ft	N/A	**ND**	**0.034**	ND	0.025	0.023
Santa Maria	N	29 ft	**ND**	**ND**	**0.035**	ND	0.034	0.020
	NE	30 ft	**0.098**	**ND**	**0.038**	ND	0.025	0.042
	E	30 ft	**0.410**	**0.294**	**0.186**	0.054	0.038	0.263
	SE	30 ft	**0.531**	**0.310**	**0.069**	0.081	0.044	0.232
	S	30 ft	**0.270**	**0.273**	**0.051**	0.048	0.035	0.156
	SW	29 ft	**ND**	**ND**	**0.048**	0.012	ND	0.026
	W	28 ft	**ND**	**ND**	**0.021**	ND	ND	0.012
	NW	28 ft	**ND**	**ND**	**ND**	ND	ND	ND

[1] the peak 24-hour time-weighted average is derived from the concentrations in bold. When the 24-hour average includes a period of no detectable amount, ½ the reporting limit was used to obtain the 24-hour average.

ND = No detectable amount; reporting limit = 0.006 ppm for 5-hr samples, 0.005 ppm for 6-hr samples and 0.003 ppm for 12-hr samples.

[2] The 24-hr TWA is an 18-hr TWA which is assumed to be representative for 24 hours.

Table 5. Ambient methyl bromide air concentrations associated with the Shank-In applications.

Sampler			Methyl Bromide (ppm) for each Sampling Period					
			Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	24-Hour
Plot	Site	Distance	4 Hour	6 Hour	12 Hour	12 Hour	12 Hour	TWA [1]
Seal Beach	N	29 ft	**0.164**	**0.118**	**0.081**	0.081	0.039	0.106
	NE	30 ft	**0.131**	**0.194**	**0.024**	0.027	ND	0.090
	E	30 ft	**ND**	**0.186**	**0.055**	0.008	ND	0.081
	SE	31 ft	**ND**	**0.067**	**0.119**	ND	ND	0.084
	S	28 ft	**ND**	**0.041**	**0.323**	ND	ND	0.188
	SW	28 ft	**ND**	**ND**	ND	ND	ND	ND
	W	27 ft	**ND**	**0.010**	**0.029**	ND	0.006	0.020
	NW	28 ft	**ND**	**ND**	**0.026**	ND	0.021	0.016
Santa Maria	N	30 ft	N/A	**ND**	**0.073**	0.029	0.026	0.049[2]
	NE	30 ft	N/A	**ND**	**0.087**	ND	0.045	0.059
	E	30 ft	N/A	**0.471**	**0.153**	0.143	0.049	0.259
	SE	30 ft	N/A	**0.357**	**0.101**	0.149	0.057	0.187
	S	30 ft	N/A	**0.231**	**0.095**	0.194	0.043	0.141
	SW	29 ft	N/A	**ND**	**0.023**	ND	ND	0.016
	W	29 ft	N/A	**ND**	**0.024**	ND	ND	0.017
	NW	29 ft	N/A	**ND**	**ND**	ND	ND	ND

[1] the peak 24-hour time-weighted average is derived from the concentrations in bold. When the 24-hour average includes a period of no detectable amount, ½ the reporting limit was used to obtain the 24-hour average.

ND = No detectable amount; reporting limit = 0.008 ppm for 4-hr samples, 0.005 ppm for 6-hr samples and 0.003 ppm for 12-hr samples.

[2] The 24-hr TWA is an 18-hr TWA which is assumed to be representative for 24 hours.

Table 6. Collocated monitoring results. Numbers are significant to two or three digits.
Extra digits are for computational purposes.

SEAL BEACH

	Period	Site No.	Concentration (ug/m3) CDFA	Bolsa* (adj)	Bolsa** (unadj)	Concentration (ppb) CDFA	Bolsa* (adj)	Bolsa** (unadj)
North field Broadcast	1	N	114.21	68.58	51.44	29.54	17.74	13.30
	2	N	71.16	89.33	67.00	18.40	23.10	17.33
	3	S	67.06	77.40	58.05	17.34	20.02	15.01
	4	N	102.10	174.08	130.56	26.41	45.02	33.77
	5	N	107.08	192.61	144.46	27.69	49.82	37.36
Shank-In	1	NE	861.47	505.49	379.12	222.80	130.74	98.05
	2	NE	579.15	779.16	584.37	149.79	201.52	151.14
	3	NE	59.59	92.24	69.18	15.41	23.86	17.89
	4	NE	123.77	104.62	78.47	32.01	27.06	20.29
	5	NE	35.25	8.91	6.68	9.12	2.30	1.73
Shank-Ahead	2	NE	777.51	1272.42	954.32	201.09	329.09	246.82
	3	NE	82.71	116.77	87.58	21.39	30.20	22.65
	4	NE	172.60	191.91	143.93	44.64	49.63	37.23
	5	NE	49.42	33.80	25.35	12.78	8.74	6.56

SANTA MARIA

	Period	Site No.	CDFA	Bolsa* (adj)	Bolsa** (unadj)	CDFA	Bolsa* (adj)	Bolsa** (unadj)
Broadcast	1	E	377.73	414.34	306.61	97.69	107.16	79.30
	2	E	418.77	656.71	485.96	108.31	169.85	125.69
	3	E	277.62	883.51	653.80	71.80	228.50	169.09
	4	E	0.00	214.70	158.88	0.00	55.53	41.09
	5	E	79.75	130.82	96.81	20.63	33.83	25.04
Shank-Ahead	1	E	1802.55	1585.67	1173.39	466.20	410.10	303.48
	2	E	964.51	1136.85	841.27	249.45	294.02	217.58
	3	E	270.70	720.20	532.95	70.01	186.27	137.84
	4	E	120.20	209.71	155.18	31.09	54.24	40.14
	5	E	61.38	146.84	108.67	15.88	37.98	28.10
Shank-In	2	E	1195.18	1820.83	1347.42	309.11	470.93	348.48
	3	E	383.83	591.06	437.39	99.27	152.87	113.12
	4	E	151.32	552.36	408.75	39.14	142.86	105.71
	5	E	64.62	190.46	140.94	16.71	49.26	36.45

*Bolsa concentrations adjusted for 75% and 74% average laboratory recovery for Seal Beach and Santa Maria, respectively. No recovery adjustment for CDFA laboratory data.
**Unadjusted Bolsa concentrations.

Table 7. Summary of Regression Calculations Used to Estimate Flux

	Seal Beach			Santa Maria		
Broadcast	Flux Estimate (ug/m2s)	R2 (%)	p (%)	Flux Estimate (ug/m2s)	R2 (%)	p (%)
1	21	85	0.12	113	48	5.7
2	70	78	0.36	110	68	1.2
3	16	75	0.52	45*	66*	*
4	44	78	0.36	66*	87*	*
5	23	89	0.05	16	72	0.8
Shank In						
1	165	57	3	NA	NA	NA
2	234	75	0.58	278	64	1.7
3	113*	94*	*	30	57	3
4	47	70	0.96	181	78	0.4
5	15	83	0.16	25	89	0.04
Shank Ahead						
1	NA	NA	NA	351	49	5.2
2	425	80	0.27	246	84	0.1
3	46*	76*	*	36*	69*	*
4	63	82	0.18	57	52	4.2
5	20	90	0.03	18	73	0.7

*Initial regression not significant (p>10%), regression on sorted values

Table 8. Average flux calculations

	Seal Beach			Santa Maria		
Treatment	Period	Period Length (hours)	Flux (ug/m2s)	Period	Period Length (hours)	Flux (ug/m2s)
Broadcast	1	5	21	1	5	113
	2	6	70	2	6	110
	3	12	16	3	12	45
	Tot/Avg	23	31.2	Tot/Avg	23	76.7
Shank In	1	4	165	2	6	278
	2	6	234	3	12	30
	3	12	113			
	Tot/Avg	22	155.5	Tot/Avg	18	112.7
Shank Ahead	2	6	425	1	5	351
	3	12	46	2	6	246
				3	12	36
	Tot/Avg	18	172.3	Tot/Avg	23	159.3

Note: Flux calculations based on concentrations adjusted for laboratory recovery: 75% Seal Beach, 74% Santa Maria

Table 9. Emission ratio calculations using 454 g/lb, formulated product 66% methyl bromide.

Seal Beach	Flux (ug/m2s)	Area (m2)	24 hours (secs)	Emission (g)	Emission (lbs)	Total Applied Mass (lbs)*	Applied Methyl Bromide (lbs)	Emission Ratio
Broadcast	31.17	3978.87	86400	10716.81	23.61	277	185.59	0.13
Shank In	155.45	4232.80	86400	56851.94	125.22	264	176.88	0.71
Shank Ahead	172.33	4143.85	86400	61700.33	135.90	263	176.21	0.77
Santa Maria								
Broadcast	76.74	3999.34	86400	26516.70	58.41	266	178.22	0.33
Shank In	112.67	4155.53	86400	40451.58	89.10	260	174.20	0.51
Shank Ahead	159.26	4136.33	86400	56916.42	125.37	366	245.22	0.51

*Santa Maria estimated by subtracting 20 lbs from weighed mass.

Table 10. Statistical analysis of emission ratio and maximum 24 hour concentration data. Treatment codes are 1=broadcast, 2=shank in, 3=shank ahead. Location codes are 1=Seal Beach, 2=Santa Maria

Emission Ratio	Maxim. 24 hr Concentration	Treatment Code	Location Code
0.13	0.049	1	1
0.71	0.188	2	1
0.77	0.166	3	1
0.33	0.187	1	2
0.51	0.259	2	2
0.51	0.263	3	2

Analysis of emission ratio

SOURCE	DF	SS	MS	F	P
TTMNT	2	0.2089	0.1045	3.34	NS
LOC	1	0.0113	0.0113	0.36	NS
ERROR	2	0.0625	0.0313		
TOTAL	5	0.2827			

Analysis of maximum 24 hour concentration

SOURCE	DF	SS	MS	F	P
TTMNT	2	0.013682	0.006841	12.0	7.7%
LOC	1	0.015606	0.015606	27.4	3.5%*
ERROR	2	0.001141	0.000570		
TOTAL	5	0.030429			

Mean values

	Emission Ratio	Maximum 24 hr Conc (ppm)			Emission Ratio	Maximum 24 hour Conc (ppm)
Broad cast	0.23	0.12		Seal Beach	0.54	0.13
Shank In	0.61	0.22		Santa Maria	0.45	0.24
Shank Ahead	0.64	0.21				

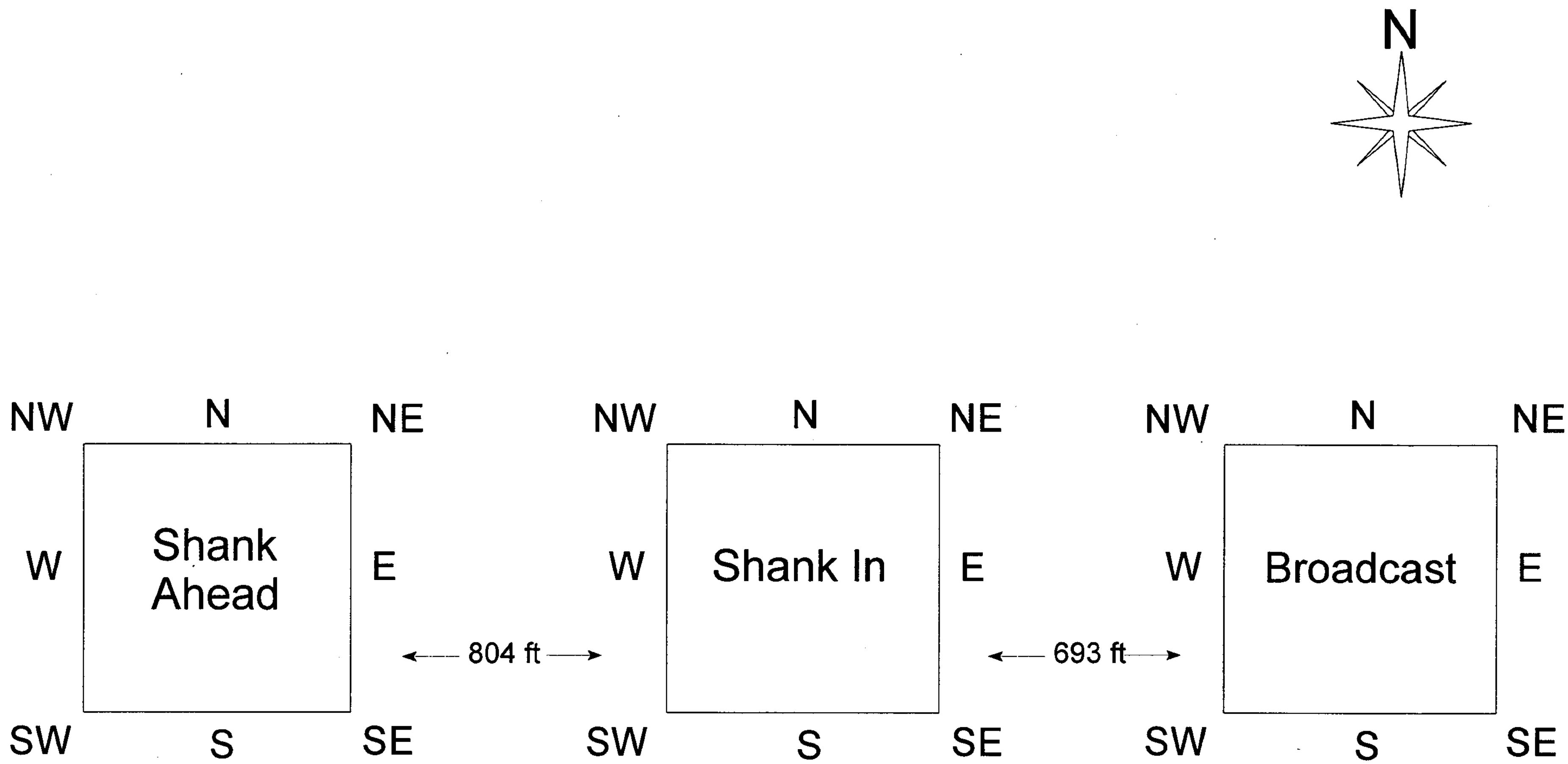

Figure 1. Seal Beach application plots.

NOT TO SCALE

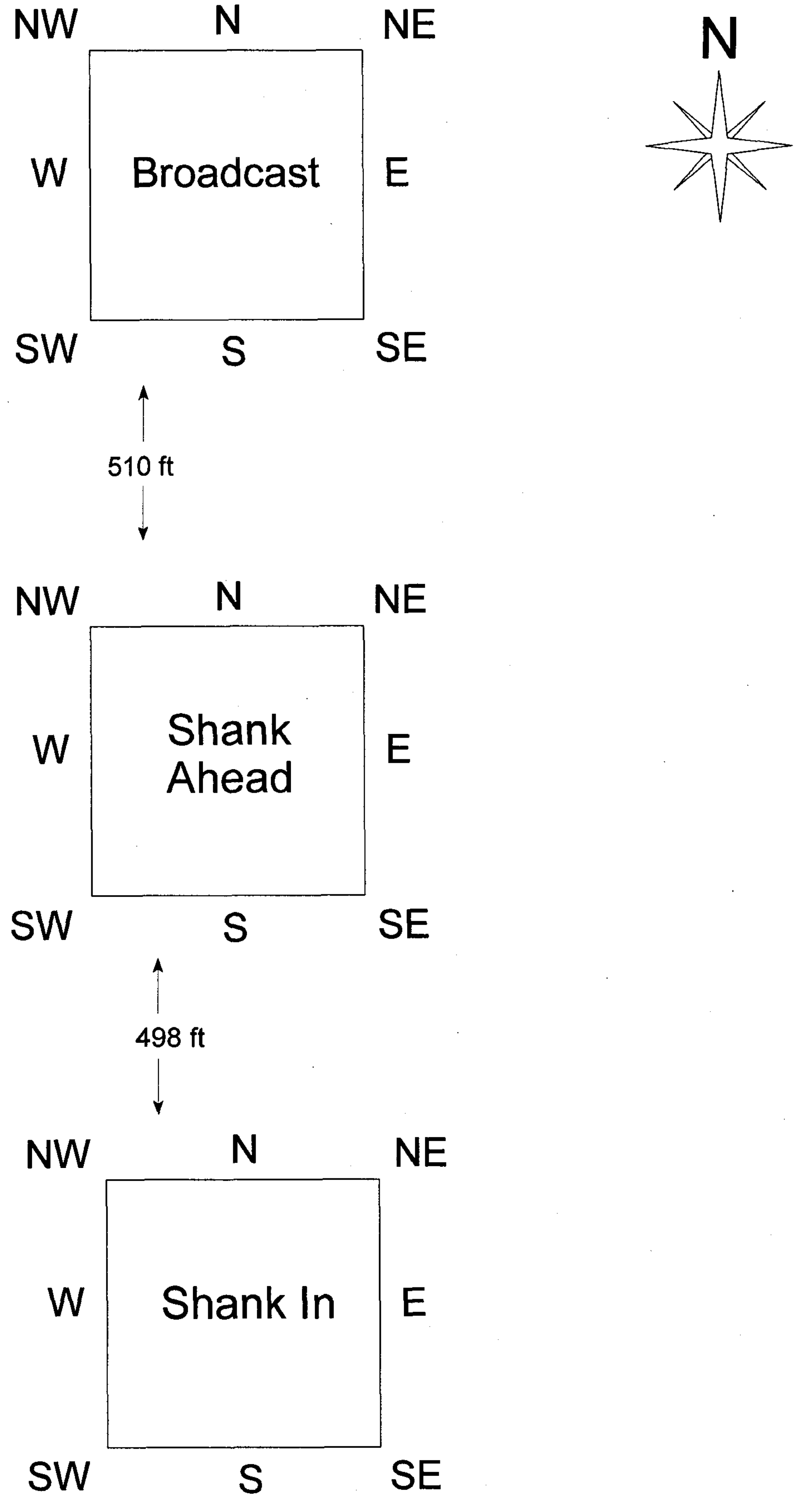

Figure 2. Santa Maria application plots.

NOT TO SCALE

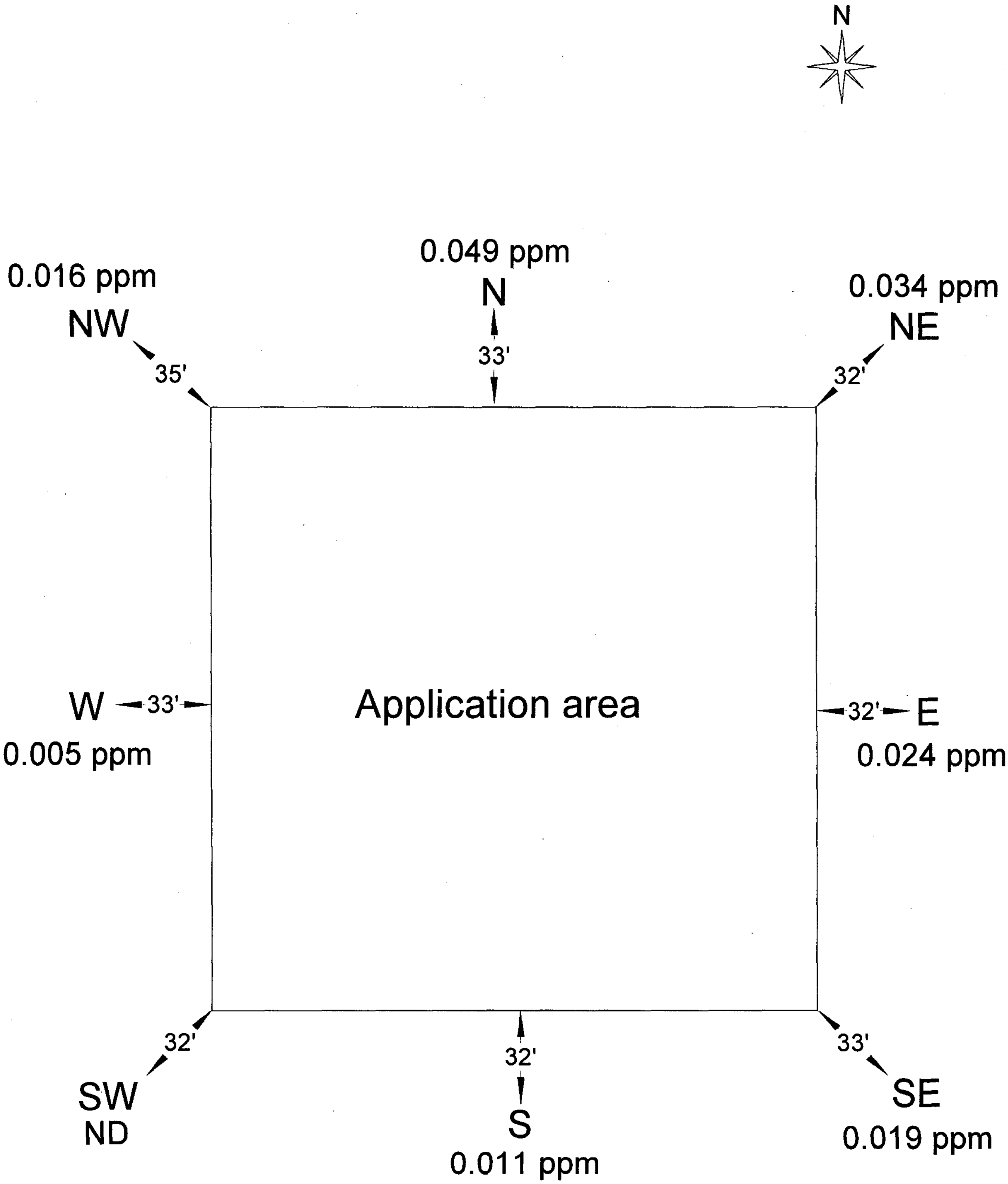

Figure 3. Seal Beach broadcast application plot and 24-hour time weighted average concentrations (ppm) for each sample site.

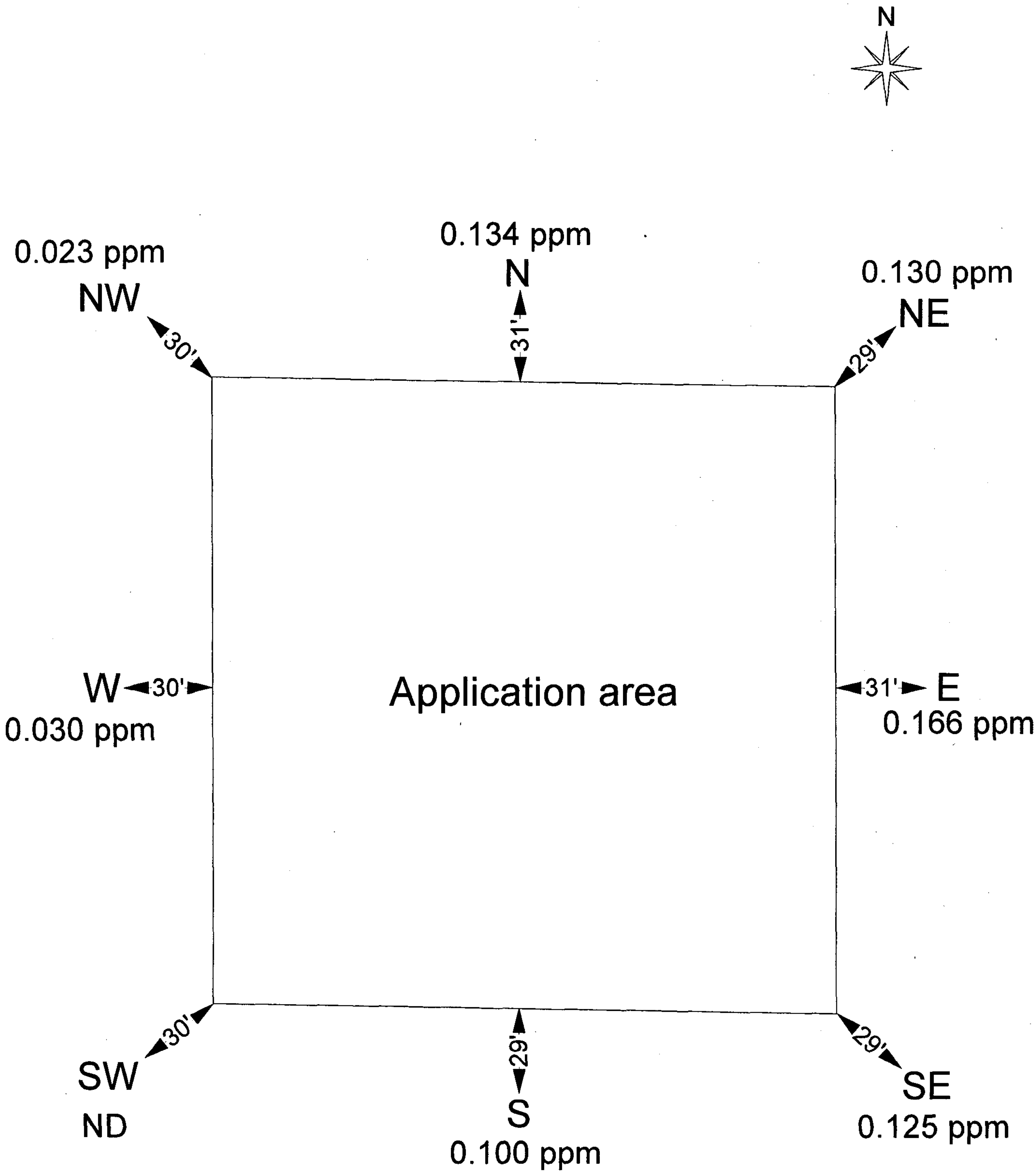

Figure 4. Seal Beach shank-ahead application plot and 24-hour time weighted average concentrations (ppm) for each sample site.

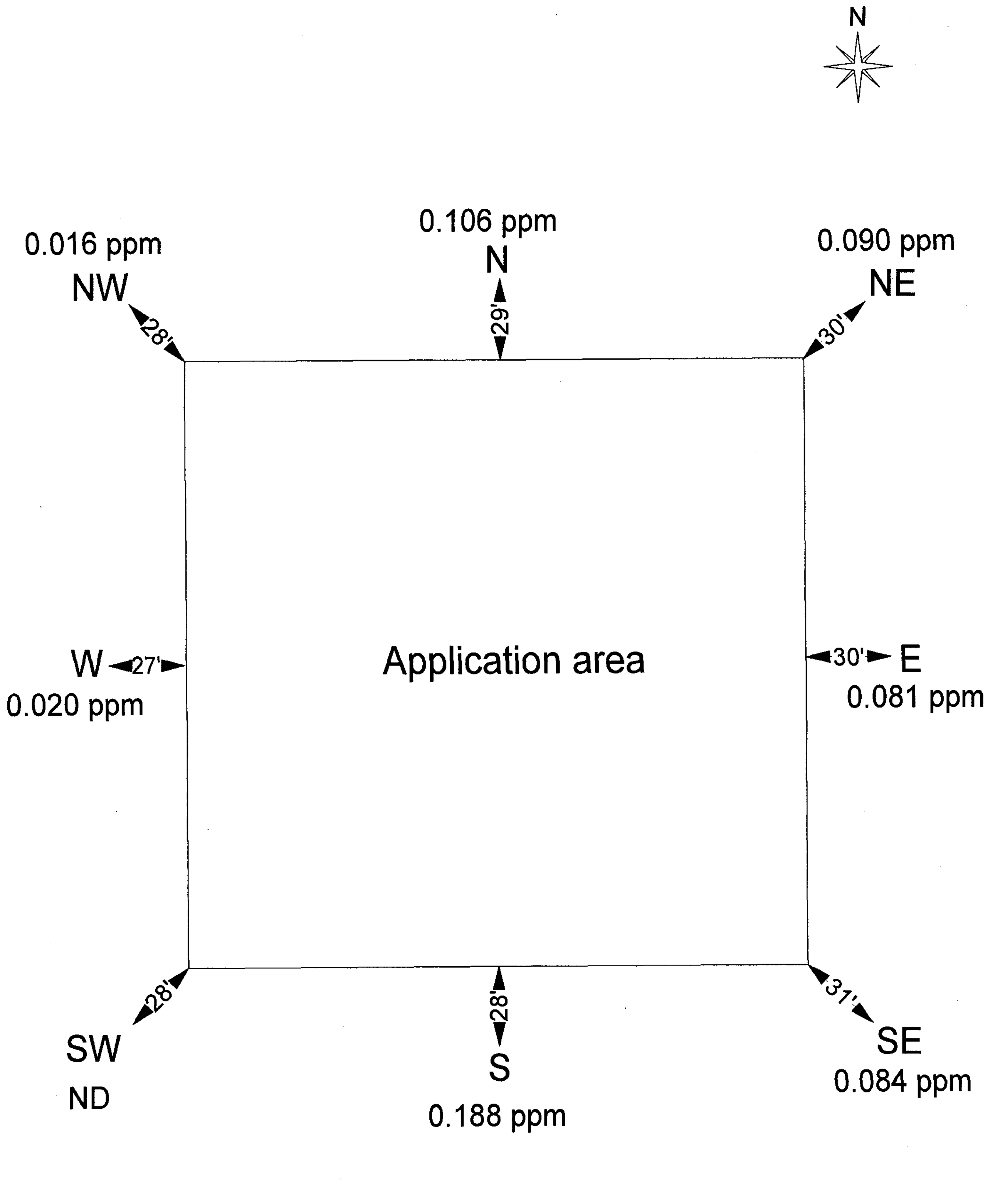

Figure 5. Seal Beach shank-in application plot and 24-hour time weighted average concentrations (ppm) for each sample site.

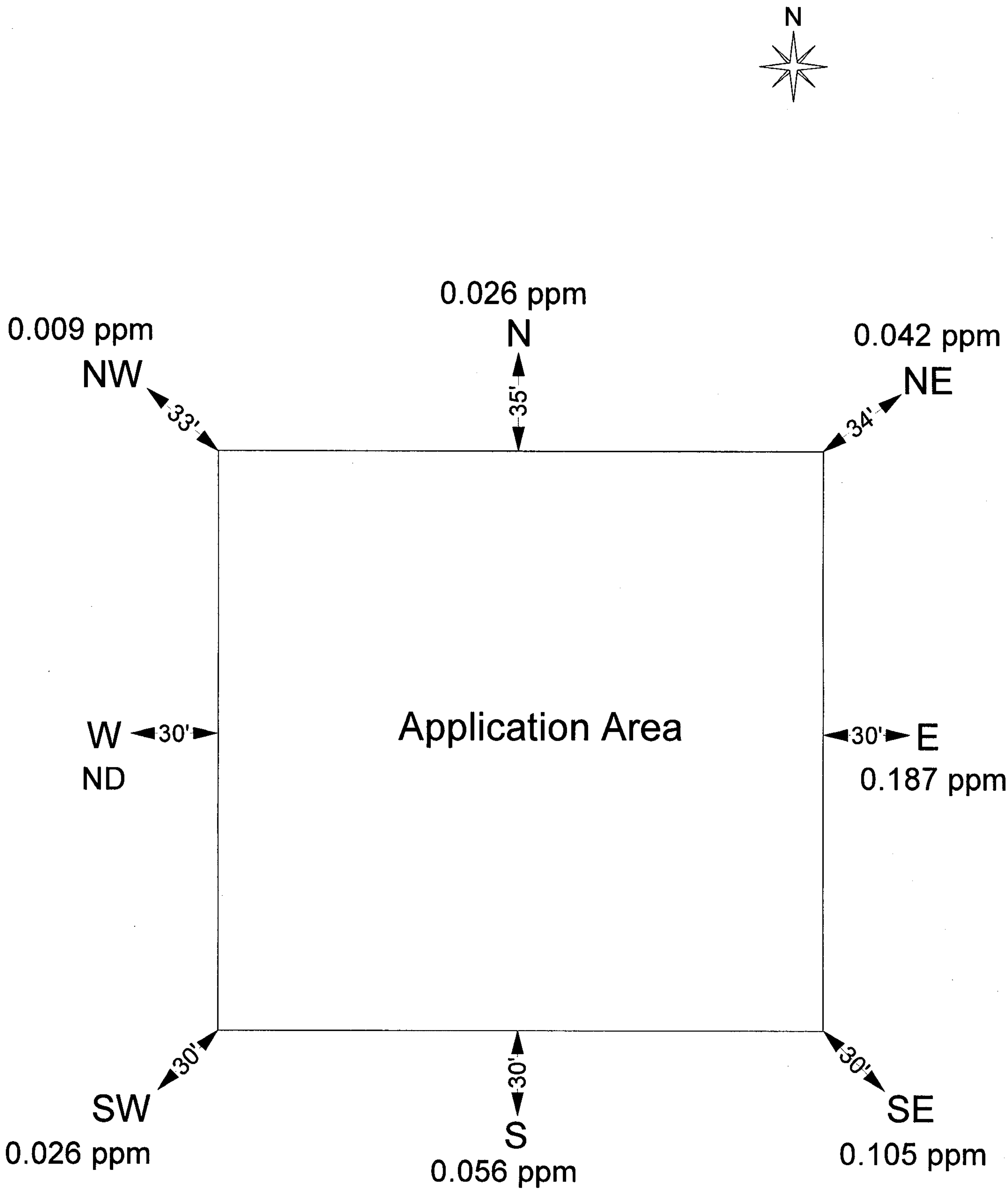

Figure 6. Santa Maria broadcast application plot and 24-hour time weighted average concentrations (ppm) for each sample site.

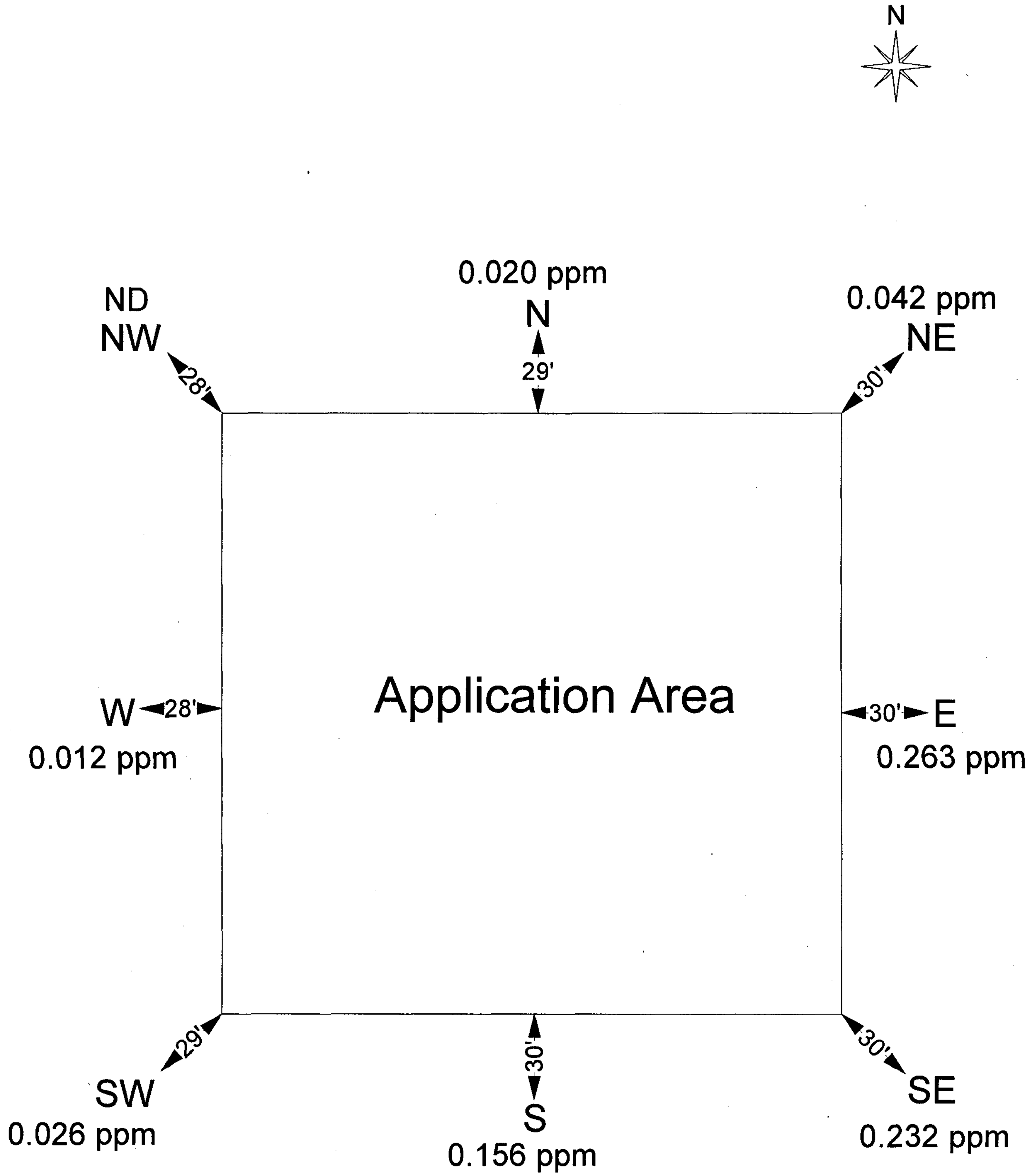

Figure 7. Santa Maria shank-ahead application plot and 24-hour time weighted average concentrations (ppm) for each sample site.

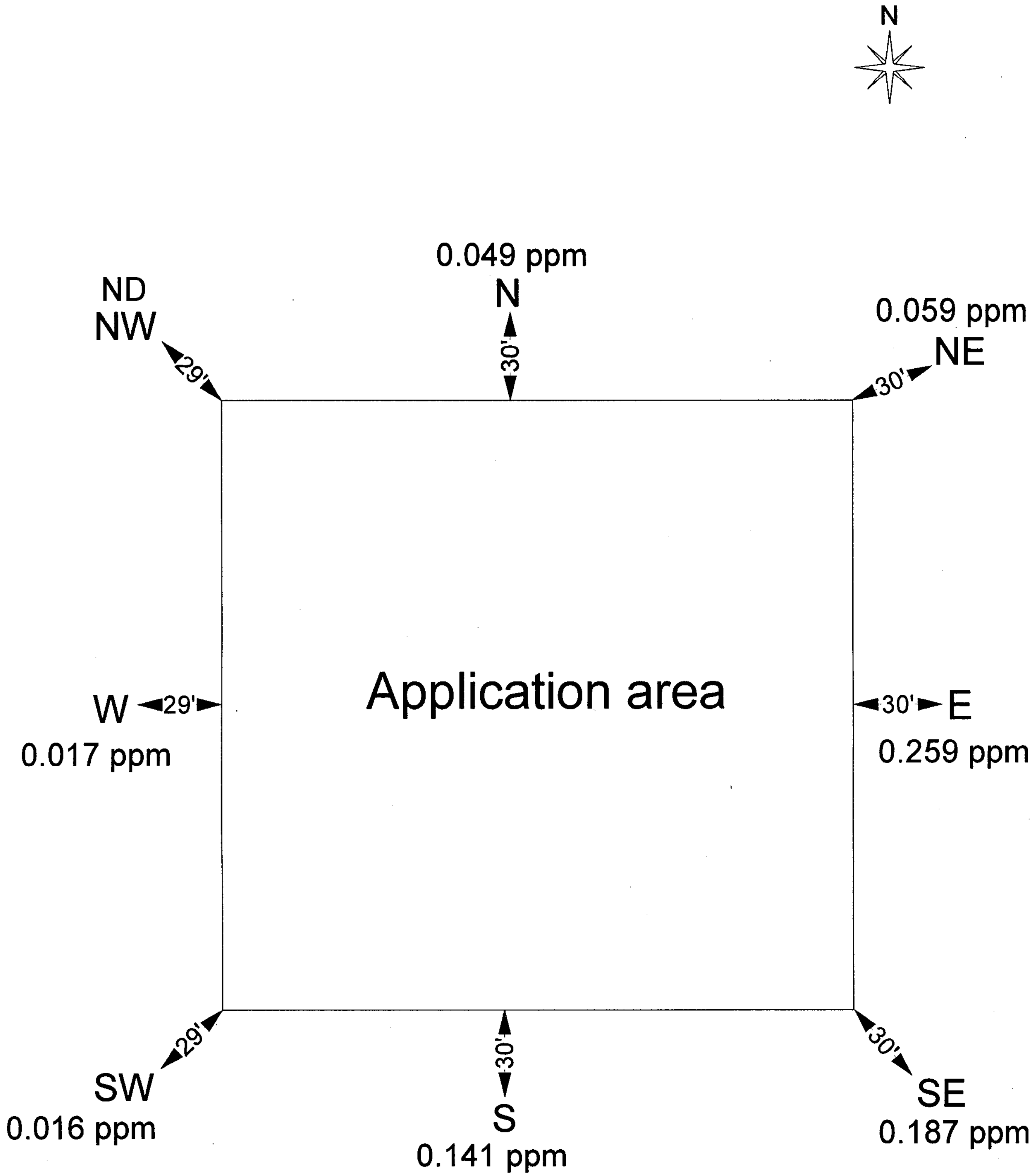

Figure 8. Santa Maria shank-in application plot and 24-hour time weighted average concentrations (ppm) for each sample site.

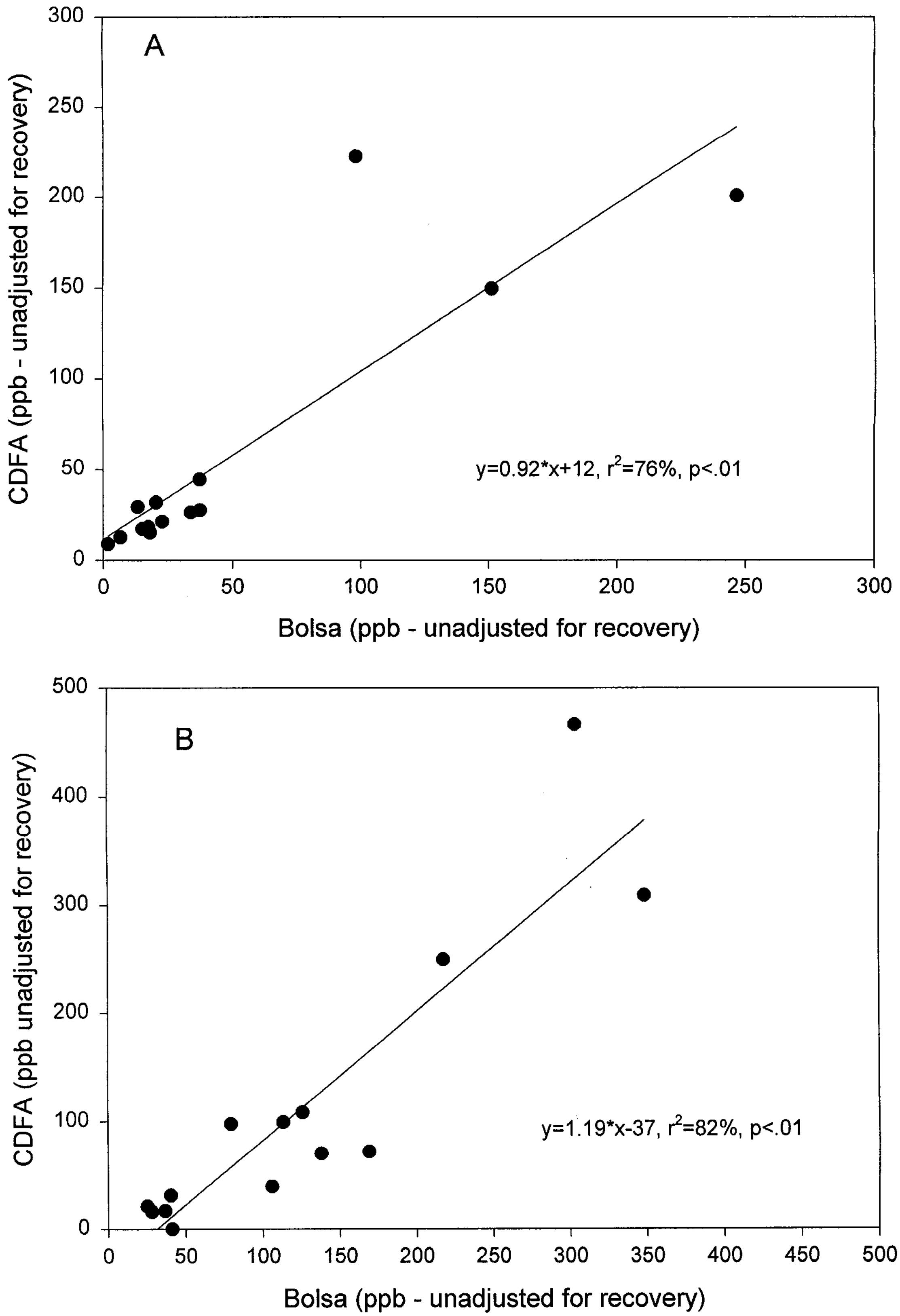

Figure 9. Comparison of collocated monitoring results between CDFA and Bolsa laboratories. Figure A contains results from Seal Beach and Figure B contains results from Santa Maria. Both regressions highly significant, and both slopes were not statistically different from 1.0 ($p>0.05$)

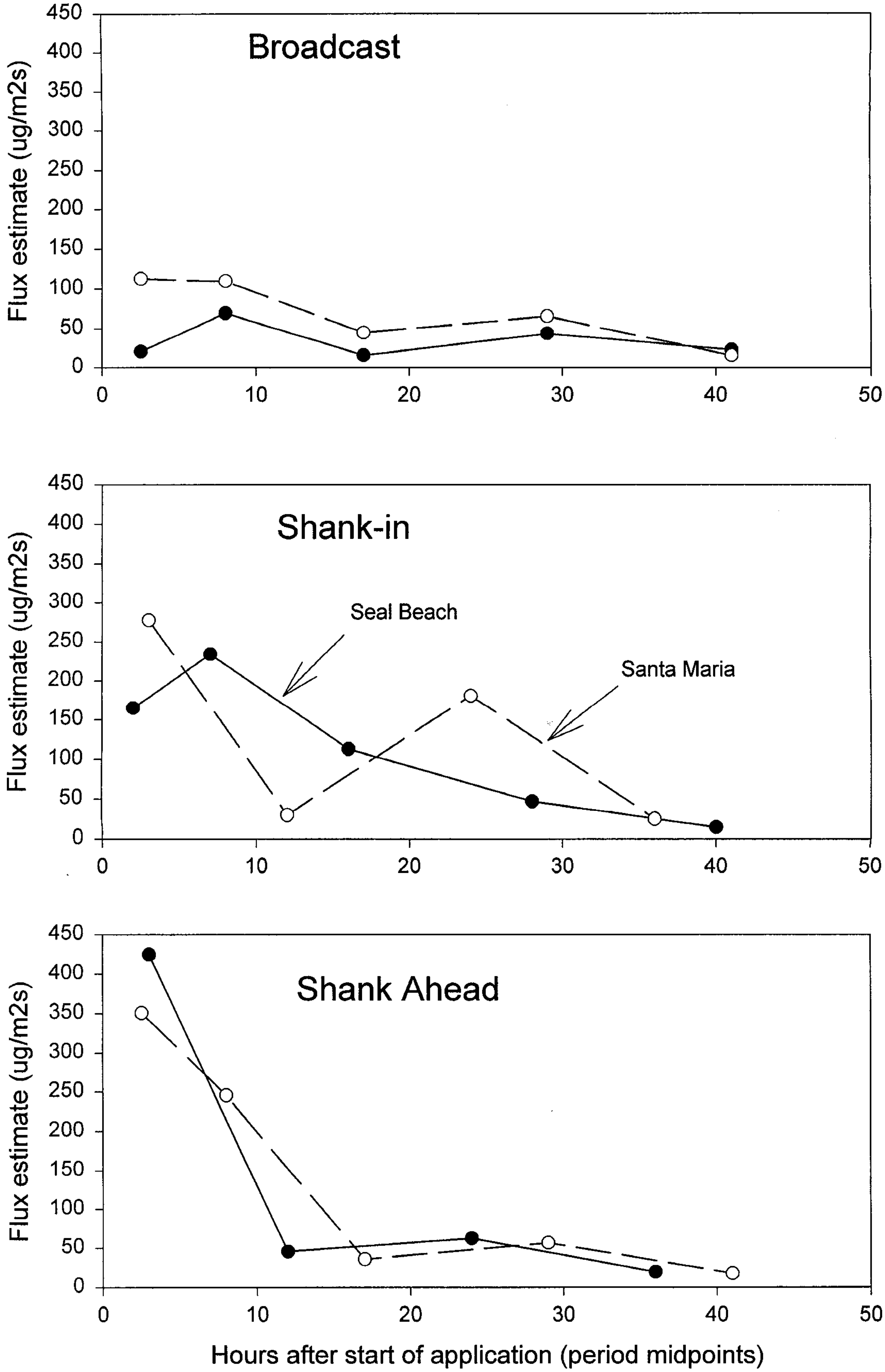

Figure 10. Backcalculated flux densities for Seal Beach (solid circles) and Santa Maria (open circles) by treatment over time.